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ABSTRACT

A multiple-group, single-intervention intensive time-series design was used to examine the achievement of an abstract concept, plate tectonics, of students grouped on the basis of cognitive tendency. Two questions were addressed: (1) How do daily achievement patterns differ between formal and concrete cognitive tendency groups when learning an abstract concept such as plate tectonics? (2) Can regression models be created which highlight differences between cognitive tendency groups? To answer these questions data were collected from students of one eighth-grade earth science teacher (N=133) and of one ninth-grade earth science teacher (N=103). The analyses conducted indicate that formal cognitive tendency students outperformed concrete cognitive tendency students while learning plate tectonics. No definite trend in group achievement was present for the concrete cognitive tendency group while a strong positive trend was evident with the formal cognitive tendency group. Regression models which explained up to 67% of the variance observed in daily group achievement were generated. Different regression models were generated for each group in the study. (Author)

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MONITORING THE PERFORMANCE OF GROUPS OF FORMAL AND CONCRETE
COGNITIVE TENDENCY STUDENTS USING AN INTENSIVE TIME-SERIES DESIGN

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COGNITIVE TENDENCY STUDENTS USING AN INTENSIVE TIME-SERIES DESIGN

Abstract

A multiple-group single-intervention intensive time-series design was used to examine the achievement on an abstract concept, plate tectonics, of students grouped on the basis of cognitive tendency. Two questions were addressed: 1) How do daily achievement patterns differ between formal and concrete cognitive tendency groups when learning an abstract concept such as plate tectonics, 2) can regression models be created which highlight differences between cognitive tendency groups. To answer these questions data were collected from students of one eighth-grade earth science teacher (n=133) and of one ninth-grade earth science teacher (n=103).

The analyses conducted indicate that formal cognitive tendency students outperformed concrete cognitive tendency students while learning plate tectonics. No definite trend in group achievement was present for the concrete cognitive tendency group while a strong positive trend was evident with the formal cognitive tendency group. Regression models which explained up to 67% of the variance observed in daily group achievement were generated. Different regression models were generated for each group in the study.

MONITORING THE PERFORMANCE OF GROUPS OF FORMAL AND CONCRETE COGNITIVE TENDENCY STUDENTS USING AN INTENSIVE TIME-SERIES DESIGN

The intensive time-series design has been shown to be a valid method for monitoring group performance on a variety of criteria; Farnsworth and Mayer, 1984; Mayer and Rojas, 1983; Mayer and Kozlow, 1980, Mayer and Lewis, 1979). The design has also been shown to yield discriminating information about group achievement (Farnsworth and Mayer, 1984). In this study the intensive time-series design was used to examine the achievement of eighth- and ninth-grade earth-science students on an abstract concept, plate tectonics. Grouping was conducted on the basis of cognitive tendency. The study sought information on the following questions: 1) How does the pattern of learning on abstract concepts such as plate tectonics differ between groups of different cognitive tendency. 2) Can regression models be created which highlight differences between cognitive tendency groups.

SAMPLE

Data were collected from students of two earth science teachers. Teacher 1, with 103 ninth-grade students, and Teacher 2, with 133 eighth-grade students taught at different schools located in middle to upper socioeconomic suburban communities near Columbus, Ohio. Students of both teachers were grouped on the basis of cognitive tendency using student ranking on the Test of Logical Thinking (TOLT) (Tobin and Capie, 1980). Three groups

of approximately equivalent size were formed, a Formal cognitive tendency group, a Concrete cognitive tendency group, and a third, middle group whose data were not used in the study.

DESIGN

A multiple-group single-intervention time-series design (Glass, Willson, Gottman, 1975) was used to collect daily data on achievement using a unit on plate tectonics as the intervention. Single multiple-choice items drawn from a pool of 75 plate tectonics items were randomly assigned to students in each of the three cognitive tendency groups.

Two multiple-item instruments were constructed from the pool of 75 plate tectonics achievement items. These instruments were administered on the first day of the Followup stage of the study to all students. These forms each contained 32 unique items and 11 common items. Form A reliability (Cronbach's alpha) was found to be 0.87; Form B reliability was 0.88.

The implementation of the intensive time-series design yielded slightly different temporal sequencing for Teacher 1 and Teacher 2. This sequencing is presented below in Campbell and Stanley (1963) notation.

T1:	0 ₁	0 ₂	...	0 ₁₀	I0 ₁₁	I0 ₁₂	...	I0 ₃₆	0 ₃₇	0 ₃₈	...	0 ₅₀
T2:	0 ₁	0 ₂	...	0 ₁₇	I0 ₁₈	I0 ₁₉	...	I0 ₄₂	0 ₄₃	0 ₄₄	...	0 ₅₄
	-----				-----				-----			
	BASELINE				INTERVENTION				FOLLOWUP			

Where: 0 represents an item administered to each group member
I indicates the occurrence of intervention

Scores were pooled to form daily group scores using Rasch procedures. (Rasch, 1960; Wright, 1977, Monk, 1984).

ANALYSIS

Any time series data may display autocorrelation of error terms. For this reason the first analyses conducted were autogressions (Willson, 1982). In all cases, autocorrelation, were determined not to be significant.

Visual inspection of graphed data was used to identify possible differences in either the slope or level of the daily group achievement data. Linear regressions were then run for each group for the Baseline, Intervention, and Followup stages of the study. Differences between groups at each stage and differences within each group between stages were examined using analysis of variance (ANOVA) procedures.

Multiple regressions of group achievement scores were conducted for each cognitive tendency group using maximum R^2 techniques. Regressors included trend variables (Figure 1), day of the study, material covered, and available daily attitude measures. From these regressions the best model of group performance was selected for each group. Additional regressions were conducted for the combined cognitive tendency groups of each Teacher in which cognitive tendency group membership was included in addition to the above mentioned regressors.

Insert Figure 1 about here

RESULTS

Visual examination of the data indicated that differences in achievement did exist between the Formal and Concrete cognitive tendency groups. The most obvious differences were that the

Formal groups generally did better than the Concrete groups. The Formal groups also displayed a positive trend in achievement during the Intervention period of the study not evident for the Concrete group data. (See Figures 2 and 3.)

Insert Figures 2 and 3 about here

Linear regressions confirmed the presence of positive slopes in the daily data for the Formal cognitive tendency group for each teacher during Intervention (Tables 1 and 2). Statistically significant negative slopes were found for the Baseline stage for the Concrete cognitive tendency group of Teacher 2, for the Baseline stage for the Formal group of Teacher 1, and for the Followup stage for the Formal group of Teacher 2. ANOVAs performed to compare groups for each teacher at each stage of the study indicated the Formal cognitive tendency groups significantly outperformed the Concrete cognitive tendency groups. The magnitude of the differences observed and the level of significance for those differences generally increased for each stage of the study. (See Table 3 and Table 4.)

Insert Tables 1, 2, 3, and 4 about here

Examining the data for within group differences for the Formal cognitive tendency groups shows a progression of significant differences from the Baseline through the Followup stages of the study: the Baseline group mean score is less than

the Intervention group mean score which in turn is less than the Followup group mean score. For both Concrete groups the Baseline group mean score is significantly less than the Followup mean score. (Tables 5 and 6).

Insert Tables 5 and 6 about here

Multiple regressions conducted indicate no substantial model (accounting for a minimum of 25% of the variance in daily achievement scores) exists for the Concrete group of Teacher 1. For Teacher 2, a model consisting predominantly of a step function (See Figure 1) and Material Converged accounted for 43% of the variance observed in Concrete group daily scores (Table 9). Models for both the Formal groups of Teachers 1 and 2 both contained, as predictors, a trended variable indicating the presence of a strong upward trend during Intervention (Tables 7 and 10). For Teacher 2, the dominant element, however, was the stage of the study variable. Regressions of daily scores of the combined cognitive tendency groups, in both cases, contained group membership as a significant predictor of daily achievement. For Teacher 1, Group membership was the dominant factor in the model, for Teacher 2, a combination of a down-up-down and step function trends were the dominant predictors in the regression (Tables 8 and 11).

Insert Tables 7, 8, 9, 10, and 11 about here.

DISCUSSION

The analysis of the intensive time-series data collected in this study indicates that students displaying a more formal cognitive tendency outperform those displaying a more concrete cognitive tendency when learning an abstract concept such as plate tectonics. This is as would be expected from the literature. (Kamil, 1979; Lawson and Lawson, 1979; and others). The unique characteristic of this study is the use of the intensive time-series design to reveal differences in patterns of learning between two groups, whereas the typical pre-post test design can only provide information on gross differences in achievement caused by intervention. This study reveals that no definite trend is present as learning occurs with the Concrete cognitive tendency group while there is a strong positive trend as learning occurs with the Formal cognitive tendency group.

Modeling procedures used in this study do indicate different factors are involved in the generation of daily group scores, however results of these procedures are not consistent within cognitive tendency groups. This may be due to inherent differences in eighth- and ninth-grade students, due to the teacher's approach to subject matter, or due to other factors not considered in this study.

The findings of this study not only raise questions about the learning processes which generate the differences observed between groups, but also highlight the power of the intensive time-series design. This design allows researchers to investigate learning as a dynamic process. Intriguing as the differences in patterns revealed in this study are, even more so

are the day to day fluctuations in performance seen in the graphs of the daily group data. Research design used in the past are incapable of revealing this phenomenon. As further studies are conducted, the use of modeling procedures as piloted here may provide vital information about factors which are thought to influence daily classroom performance. The possible effects of such factors on the interpretation of results of other studies using more traditional designs must be recognized. Even more important for cognitive psychologists, educational researchers, and teachers are the reasons for daily changes in ability to perform. Are they the result of environmental factors, cognitive processes, social interactions, or some combination of these and/or other factors?

SELECTED BIBLIOGRAPHY

Butts, D.P. Summary of reseasrch in science education - 1979. Science Education, 1981, 65, 337-465.

Campbell, D.. and Stanley, J.C. Experimental and quasi-experimental designs for research. Chicago: Rand, McNally, and Company, 1963.

Cook, D., and Campbell, D.T. Quasi-experimentation: design and analysis issues for field settings. Chicago: Rand McNally College Publishing Company, 1979.

Farnsworth, C.H. and Mayer, V.J. An Assessment of the validity and discrimination of the intensive time-series design by monitoring learning differences between students. Journal of Research in Science Teaching, 1984.

Glass, B.V., Willson, V.L., & Gottman, J.M. Design and analysis of time-series experiments. Boulder, Colorado: Associated University Press, 1975.

Kamii, C. Teaching for thinking and creativity: A Piagetian point of view. 1980 AETS yearbook. The Psychology of Teaching for Thinking and Creativity. Columbus, Ohio: ERIC, Clearinghouse of Science, Mathematics, and Environmental Education, The Ohio State University, 1979.

Lawson, A.E. and Lawson, C.A. A theory of teaching for conceptual understanding, rational thought, and creativity. 1980 AETS yearbook. The Psychology of Teaching for Thinking for Creativity. Columbus, Ohio: ERIC, Clearinghouse of Science, Mathematics, and Enviromental Education, The Ohio State University, 1979.

Mayer, V.J., & Kozlow, M.J. An evaluation of a time-series single subject design used in an intensive study of concept understanding. Journal of Research in Science Teaching, 1980, 17, 455-461.

Mayer, V.J., & Lewis, D.K. An assessment of the validity of the use of a time-series single subject design. Journal of Research in Science Teaching, 1979, 16, 137-144.

Mayer, V.J., & Rojas, C.A. The effect of frequency of testing upon the measurement of achievement in an intensive time-series design. Journal of Research in Science Teaching, 1982, 19, 543-551.

Monk, J.S. An examination of methods used to generate daily group scores from single-item-per-subject data collected in intensive time-series designs. Journal of Research in Science Teaching, 1984.

Neter, J., and Wasserman, W. Applied linear statistical models. Homewood, IL: Richard D. Irwin, Inc., 1974.

Raach, G. Probabilistic models for some intelligence and attainment tests. Copenhagen, Denmark: Paedagogiske Institute, 1960.

Tobin, K.G., and Capie, W., The development and validation of a group test of logical thinking. Educational and Psychological Measurement. 1981, 41, 413-424.

Willson, V.L. More on time series designs: A re-analysis of Mayer and Kozlow's Data. Journal of Research in Science Teaching. 1982, 19, 571-575.

Wright, B.D. Solving measurement problems with the Rasch model. Journal of Educational Measurement. 1977, 14, 97-116.

TABLE 1
Summary of Linear Regressions of Achievement by Day for
Teacher 1: Cognitive Tendency Groups

Group	Stage	df	F	p	r ²	Slope
Concrete	Baseline	1/8	3.41	0.10	0.30	
	Intervention	1/24	3.89	0.06	0.14	
	Follow-up	1/12	1.32	0.27	0.10	
Formal	Baseline	1/8	9.25	0.02	0.54	-0.115
	Intervention	1/24	4.36	0.05	0.15	0.029
	Follow-up	1/12	0.01	0.91	0.00	

TABLE 2
Summary of Linear Regressions of Achievement by Day for
Teacher 2: Cognitive Tendency Groups

Group	Stage	df	F	p	r ²	Slope
Concrete	Baseline	1/15	7.80	0.01	0.34	-0.067
	Intervention	1/23	0.25	0.62	0.01	
	Follow-up	1/10	0.45	0.52	0.04	
Formal	Baseline	1/15	0.00	0.97	0.00	
	Intervention	1/23	17.11	0.0004	0.43	0.046
	Follow-up	1/10	4.95	0.05	0.33	-0.059

TABLE 3

Summary of Achievement ANOVAs for Teacher 1:
Comparing Cognitive Tendency Groups

Stage of Comparison	df	MS	F	p
Baseline	1	1.55	8.75	.008
Intervention	1	9.45	33.83	.0001
Follow-up	1	13.60	76.69	.0001
Relevant Means:	Concrete		Formal	
Baseline (n=10)	2.43		2.98	
Intervention (n=26)	2.65		3.50	
Follow-up (n=14)	2.79		4.19	

TABLE 4

Summary of Achievement ANOVAs for Teacher 2:
Comparing Cognitive Tendency Groups

Stage of Comparison	df	MS	F	p
Baseline	1	1.52	6.15	.019
Intervention	1	4.39	19.85	.0001
Follow-up	1	5.59	26.93	.0001
Relevant Means:	Concrete		Formal	
Baseline (n=17)	2.03		2.46	
Intervention (n=25)	2.43		3.03	
Follow-up (n=12)	2.77		3.74	

TABLE 5
Summary of Achievement ANOVAs for Teacher 1:
Comparing Stages for the Cognitive Tendency Groups

Group	df	MS	F	p
Concrete	2	0.39	2.46	0.096
Means	2.43 Baseline	2.65 Intervention		2.79 Follow-up
Formal	2	4.44	14.63	0.0001
Scheffe' ^a	-----	-----	-----	-----
Means	2.98 Baseline	3.50 Intervention		4.19 Follow-up

^aNote: The Scheffe; follow-up is expressed as a bar joining means which are not significantly different at the $p = 0.05$ level. In this instance, there is no significant difference between Baseline and Intervention scores, however, both Baseline and Intervention scores are significantly lower than Follow-up scores.

TABLE 6
Summary of Achievement ANOVAs for Teacher 2:
Comparing Stages for the Cognitive Tendency Groups

Group	df	MS	F	p
Concrete	2	1.99	8.06	0.0009
Scheffe'	-----	-----	-----	-----
Means	2.03 Baseline	2.43 Intervention		2.77 Follow-up
Formal	2	5.01	28.31	0.0001
Scheffe'	-----	-----	-----	-----
Means	2.46 Baseline	3.03 Intervention		3.74 Follow-up

TABLE 7
Results of the Maximum R^2 Improvement Stepwise Multiple
Regression Predicting Achievement for
the Formal Cognitive Tendency Group for Teacher 1

Source	df	MS	F	p
Regression	4	2.99	12.03	0.0001
Error	45	0.24		
R^2 for Model 0.43				
Variable	B	F	p	R^2 change
Trend 3	0.012	37.12	0.0001	.043

TABLE 8
Results of the Maximum R^2 Improvement Stepwise Multiple
Regression Predicting Achievement for
the Combined Cognitive Tendency Groups for Teacher 1

Source	df	MS	f	p
Regression	4	8.30	38.45	0.0001
Error	95	0.216		
R^2 for Model 0.60				
Variable	B	F	p	R^2 change
Group	-0.945	103.26	0.001	0.42
Trend 3	0.023	8.71	0.004	0.18
Material	-0.163	4.50	0.04	0.15
Stage (b)	0.727	4.54	0.04	0.05
Stage (a)	-.---	-.---	-.---	-.---

TABLE 9
Results of the Maximum R^2 Improvement Stepwise Multiple
Regression Predicting Achievement for
the Concrete Cognitive Tendency Group for Teacher 2

Source	df	MS	F	p
Regression	4	1.78	9.30	0.0001
Error	49	0.19		
R^2 for Model 0.43				
Variable	B	F	p	R^2 change
Trend 0	0.180	10.61	0.002	0.24
Material	0.173	8.84	0.005	0.09
Plate				
Tectonics	-0.606	6.47	0.01	0.07
	-0.063	12.14	0.001	0.03

TABLE 10
Results of the Maximum R^2 Improvement Stepwise Multiple
Regression Predicting Achievement for
the Formal Cognitive Tendency Group for Teacher 2

Source	df	MS	F	p
Regression	3	4.49	34.12	0.0001
Error	50	0.14		
R^2 for Model 0.67				
Variable	B	F	p	R^2 change
Stage (a)	0.407	7.49	0.009	0.53
Stage (b)	-.----	-.--	-.----	-.--
Trend 2	0.011	22.20	0.0001	0.14

TABLE 11
Results of the Maximum R^2 Improvement Stepwise Multiple
Regression Predicting Achievement for
the Combined Cognitive Tendency Groups for Teacher 2

Source	df	MS	F	p
Regression	3	9.34	46.12	0.0001
Error	104	0.02		
R^2 for Model 0.57				
Variable	B	F	p	R^2 change
Trend 0	0.089	25.22	0.0001	0.29
Trend 4	0.007	15.11	0.0001	0.22
Group	-0.622	51.51	0.0001	0.06

FIGURE 1

Models Used to Examine Daily Data for Autocorrelation

Trend 0
The Step Function



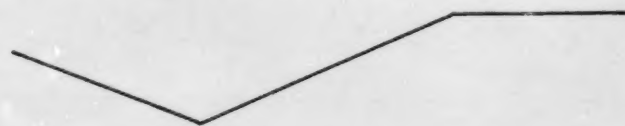
Trend 1
Simple Ascending
Ramp Function



Trend 2
Ramp Function With
Flat Baseline and
Descending Followup



Trend 3
Ramp Function
With Descending
Baseline and Flat
Followup



Trend 4
Ramp With
Descending Baseline
and Followup



Baseline Intervention Followup

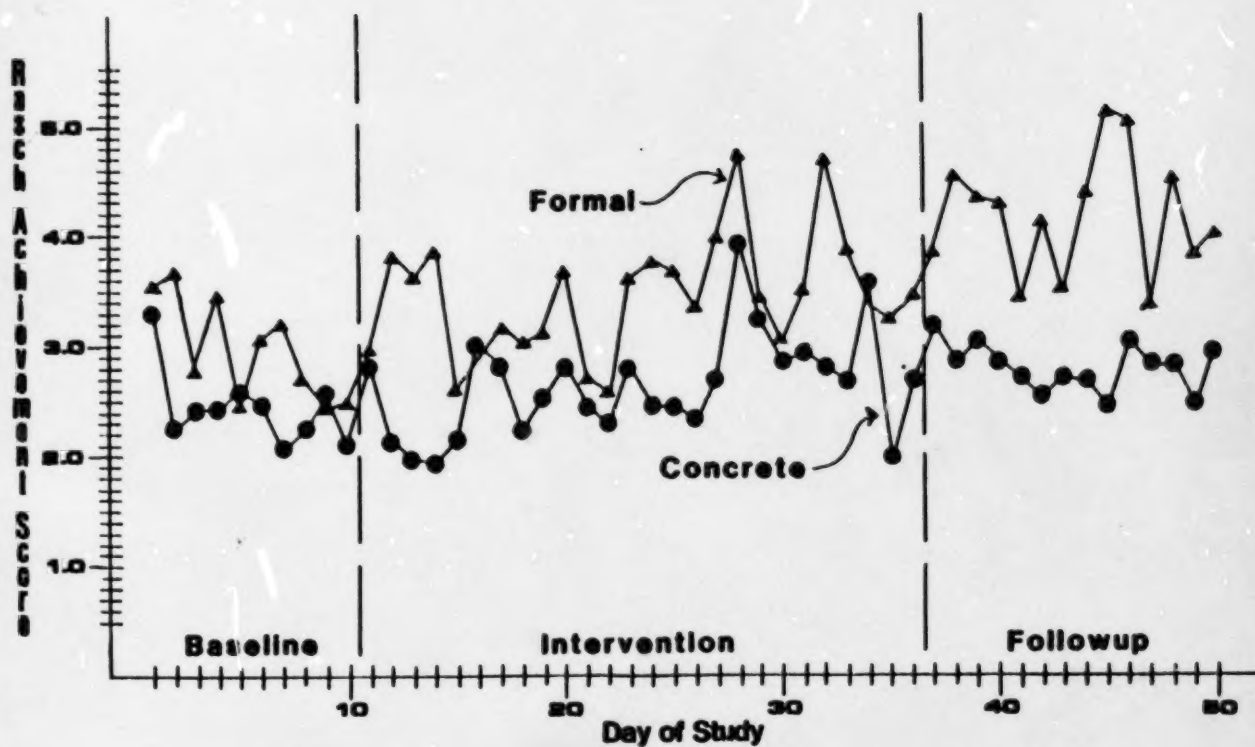


FIGURE 2

Teacher 1
Daily Rasch Achievement Scores
Cognitive Tendency Groups

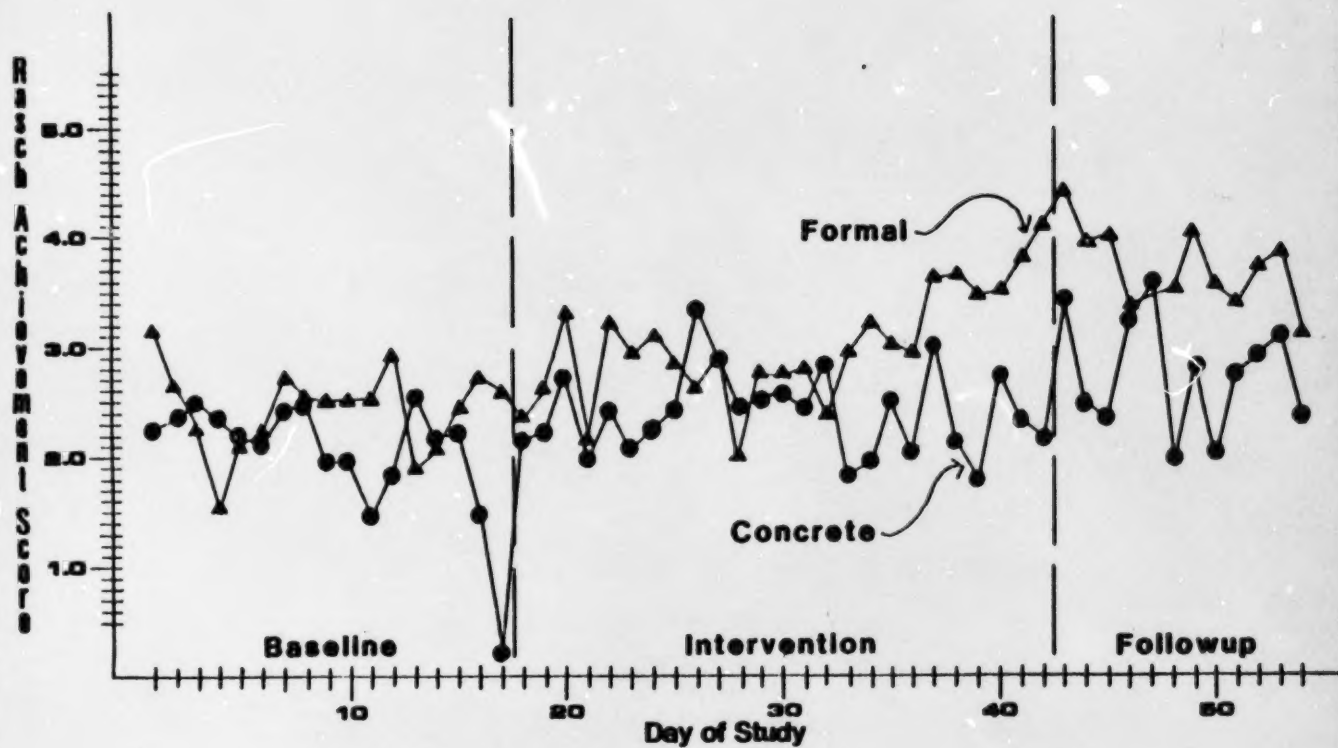


FIGURE 3

Teacher 2
Daily Rasch Achievement Scores
Cognitive Tendency Groups